

The Exterior Nebulosities of the Pleiades, with a Drawing from the different Photographs; and on the appearance of the involved Nebulosities of the Cluster with the 40-inch Refractor. By E. E. Barnard.

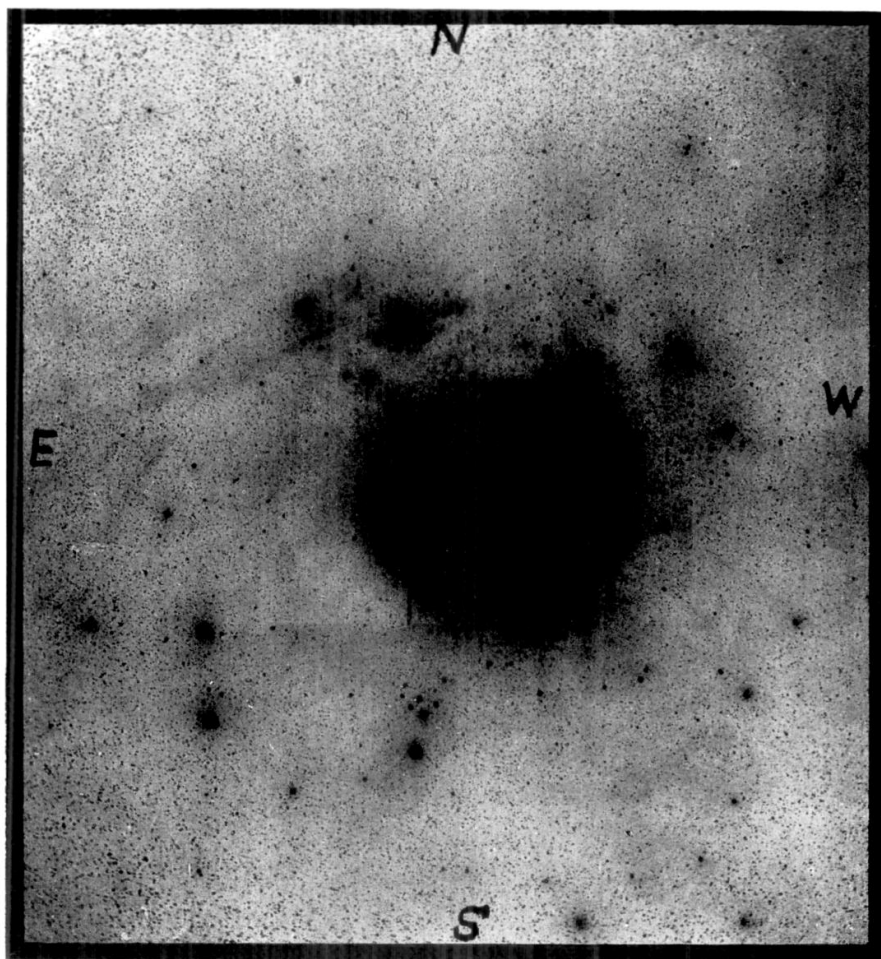
In *Astronomische Nachrichten* 3253, Bd. 136, I have given an account, with a rough chart, of what I have called the exterior nebulosities of the *Pleiades*, and which were shown on photographs made with the Willard 6-inch portrait lens in 1893 December. In that paper I have stated: "For many years, during my comet-seeking, I have known of a vast and extensive, but very diffused, nebula north of the *Pleiades*. Other masses of this diffused matter make their presence known by a general dulling of the field when sweeping in the neighbourhood of the cluster. . . . It has been my hope during the past two or three years to sometime be able to secure a photographic impression of these vague nebulosities that I had seen in the telescope. It was evident this would require a long exposure. The mounting of our Willard lens does not permit an exposure to be carried beyond the meridian; to get sufficient time would therefore require more than one night. This past winter I have been able, by carefully inclosing the camera box in thick black cloth and by taking other precautions, to extend the exposure through two nights with success. Previous to this I gave an exposure on the *Pleiades* of four hours, which showed all the well-known nebulosities and gave faint suggestions of more distant wisps of nebulae."

Circumstances prevented my securing a long-exposure photograph of the *Pleiades* in the winter of 1894, and since then I have not had an instrument for the purpose.

As in the case of the great nebula of ρ *Ophiuchi*, these nebulosities were known to me visually for many years before they were photographed. Indeed, there are other such nebulous regions elsewhere which I have seen in comet seeking, and I hope soon to be able to secure photographs of them, as in the case of the *Pleiades* and of ρ *Ophiuchi*. Some of these yet unphotographed nebulosities are, I believe, fully as remarkable as those just mentioned.

In the winter of 1898 Dr. H. C. Wilson, of Northfield, Minnesota, fully verified the exterior nebulosities of the *Pleiades*, and secured good photographs of them. In an endeavour to verify them he had secured traces as far back as 1894, with an exposure of 11^h 15^m; but the photographs of 1898, with 5^h 35^m exposure, showed them distinctly. Dr. Wilson has given an account of these photographs, with reproductions, in *Popular Astronomy* for 1899 February.

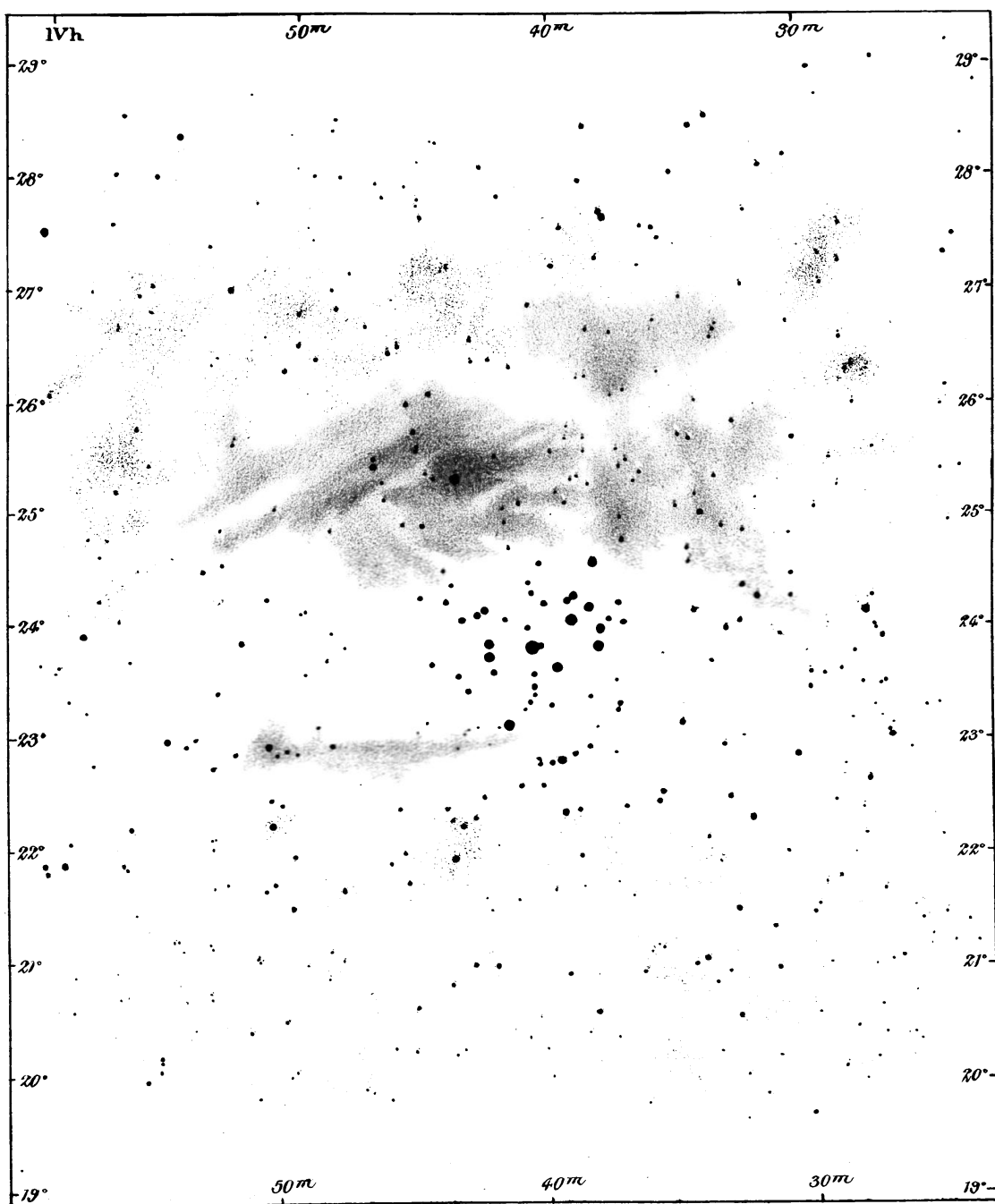
In the summer of 1898, while visiting Harvard College Observatory, I was shown, among many other interesting photographs, one of the *Pleiades* made at Arequipa, Peru, on 1897 October 29, by Professor Bailey with the 8-inch Bache telescope.



PHOTOGRAPH OF THE REGION OF THE PLEIADES,
SHOWING THE EXTERIOR NEBULOSITIES.

Made at the Arequipa, Peru, station of the Harvard College Observatory, with the 8-inch telescope,
1897 October 29. Exposure 300 minutes.

The fainter nebulosities have been brought out by successive intensifications from an original positive.



EXTERIOR NEBULOSITIES OF THE PLEIADES.

DRAWN BY E. CALVERT, FROM PHOTOGRAPHS

The exposure was 300 minutes. On this negative I could easily trace out these exterior nebulosities, though they were faint. Through the kindness of Professor E. C. Pickering I have been supplied with a glass positive of this picture, with permission to publish it (Plate 9).

This photograph readily verifies those made by me in 1893 and by Dr. Wilson in 1894 and 1898. Every detail has been perfectly and satisfactorily verified, leaving no question, in the mind of an unprejudiced person, of the existence of those singular nebulosities exterior to, but connected with, the *Pleiades*.*

One startling fact brought out by the study of these photographs is that the *Pleiades* and their involved nebulosities are but the central condensation of an enormous nebula, intricate in details, and covering at least 100 square degrees of the sky.

The great magnitude of this nebula or nebulosity appears almost beyond belief. Taken, however, in the light of other masses of nebulosity revealed by photography, such as those in *Monoceros*, in *Cygnus*, and in *Ophiuchus*, not to mention the great curved nebula stretching across a large portion of the constellation of *Orion*, it should not appear at all strange. Indeed, however strange it may appear is of little consequence, for it is an established fact that must be faced and accepted.

During the present summer I have taken advantage of a visit of Mr. E. Calvert, my brother-in-law, a skilled artist, to get him to make a careful drawing of these nebulosities from the various photographs, basing the work on the Harvard College photograph on account of its greater scale. The result is a very beautiful and accurate drawing in negative. This drawing I have forwarded with this paper, after having placed a system of coordinates around it by which the position of any feature of the nebula may be taken at sight for the epoch 1900 (Plate 10).

The drawing does not show the full extent of the nebulosities, and is therefore only a partial map of these remarkable features. The nebulosities extend for a considerable distance in all directions beyond what is shown on the drawing, which terminates rather abruptly. Especially does the nebulosity extend to the eastward much further than shown. The portion drawn covers from about $\alpha = 3^{\text{h}} 25^{\text{m}}$ to $\alpha = 4^{\text{h}} 0^{\text{m}}$, and from $\delta = +19^\circ$ to $\delta = +29^\circ$, extending thus over some ten degrees square.

It was not thought desirable to draw in the older nebulosities, as they are already so well known, and were burned out on the prints from which the drawing was made. The bright stars of the cluster, however, are shown for convenience in the study of the picture, and are inclosed in a faint circle inside of which all the previously known nebulosities are located.

The remarkable peculiarities of the nebula are strikingly shown in the drawing. It will be seen that the brightest portion

* On a recent visit to Dr. Max Wolf I was shown an excellent negative of the *Pleiades* in which the exterior nebulosities are distinctly traced. [Note added Feb. 1900].

(which ought to be easily photographed by such an instrument as the Crossley reflector at the Lick Observatory) is the centre of strongly marked details in

$$\alpha = 3^{\text{h}} 44^{\text{m}} \delta = +25^{\circ} 4.$$

This is at the 6^m star Piazzini iii. 170, which is Rad. 434, and whose position for 1860.0 is

$$\alpha = 3^{\text{h}} 41^{\text{m}} 54^{\text{s}}.30 \delta = +25^{\circ} 9' 15'' .3.$$

There is some delicate detail of a wispy nature in

$$\alpha = 3^{\text{h}} 34^{\text{m}} \text{ from } \delta = +21^{\circ} 5 \text{ to } \delta = +24^{\circ} 0.$$

Many of the details shown on this drawing will be fairly easy objects to photograph with the larger reflectors, whose scale will be big enough to show their individual peculiarities. Indeed, from what is already shown with the portrait lenses, I believe many of these details are far more interesting and peculiar than any involved in the cluster itself.

While on the subject of the *Pleiades*, I have lately, while measuring stars in the cluster, examined the inner nebulosities, and have been struck with their distinctness in the great telescope. The nebulosities in the region of *Merope* are perhaps the most striking. The following edge of the nebula of *Merope* which follows *Merope* some 5', and which on the Henry Brothers chart extends from $3^{\text{h}} 39^{\text{m}}.7$ to $3^{\text{h}} 40^{\text{m}}$, and from $\delta = +23^{\circ} 35'$ to $+23^{\circ} 40'$, is remarkably sharply defined, so much so under the best conditions that one could easily lay a micrometer wire along it to a second of arc. There are several long strips of nebulosity between this and *Merope*, which are very conspicuous objects. Even the original nebulosity discovered by Tempel, extending south-westerly from *Merope*, and which is specially suited for small telescopes, comes out very strong in the 40-inch. The small roundish nebula close to *Merope* which was found with the 36-inch in 1890, is a decidedly conspicuous object. Under the best conditions it seems somewhat irregular in outline.* The nebulosities about *Maia* are very easy, and strongly shown. The prong-like projection preceding from *Electra* is well seen, but rather faint and diffused. Some of the nebulosities about *Alcyone* could be made out, but this region is difficult from the radiance of *Alcyone* and its neighbouring stars.

I have now 120 nights' measures of the difference of declination of *Atlas* and *Pleione* for the study of temperature changes in the 40-inch object glass, and this work has frequently led me to examine the *Pleiades* and their involved nebulosities.

In conclusion, with reference to the photographs of the exterior nebulosities of the *Pleiades* made in 1893, I would refer to a previous paper of mine in *Monthly Notices*, vol. lvii. pp. 10-16, in which a photograph is reproduced in negative. For a com-

* With the 40-inch there is an excessively faint point of light on the edge of the nebulosity towards *Merope*.

parison of this with our present drawing, it must be looked at in a mirror, or must be supposed to be seen through the back of the paper, since it is reversed, or in the same condition with reference to orientation as the original negative looked at from the film side. The title of the above paper is "On the Comparison of Reflector and Portrait Lens Photographs."

That photograph has suffered in the reproduction, and does not show the exterior nebulosities as distinctly as it ought to.

On the photographs of the *Pleiades* made in 1893 December a star near *o Persei* is shown to be densely involved in nebulosity. It is 7' south of, and 3' following, *o Persei*, and is identified as DM +31°643. The position for 1855.0 is

$$\alpha = 3^h 35^m 27^s.6 \quad \delta = +31^\circ 42' 2''.$$

It is given as 8^m.2 in DM.

I have lately examined this star (which is reddish in colour) with the 40-inch, and it is surrounded for some distance with conspicuous nebulosity.

Yerkes Observatory, Williams Bay, Wisconsin :
1899 November.

On the Diameter of Ceres and Vesta. By E. E. Barnard.

During the oppositions of 1894 and 1895 a series of measures of the diameters of *Ceres* (1), *Pallas* (2), *Juno* (3), and *Vesta* (4), were made with the 36-inch of the Lick Observatory (*M.N.* vol. lvi. pp. 55-63).

The diameters thus obtained were (reduced to $\Delta 2.7673$) :—

Ceres	...	...	0".389	23 nights
Pallas	...	...	0".244	5 "
Juno	...	...	0".095 ±	4 "
Vesta	...	...	0".195	18 "

I have endeavoured to redetermine these diameters here with the large telescope, but the conditions have not been favourable for the use of sufficiently high power for the purpose. A few nights' measures, however, were obtained of *Ceres* and *Vesta*. These, though not considered so satisfactory as the measures which I secured in 1894 and 1895, verify the diameters then obtained, and show that they can be relied upon as being as accurate as can be secured by the work of one observer.

The following are the only measures it has been possible to secure with the 40-inch.

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